CLAIMS

What is claimed is:

1. A hinge apparatus comprising:

a hinge pin formed of a two-way shape memory alloy (SMA) adapted to transition, without an externally applied load, between a first trained shape and a second trained shape upon switching the two-way SMA between a first state and a second state;

wherein switching the two-way SMA from the first state to the second state causes the hinge apparatus to apply an opening force to a device coupled to the hinge apparatus; and

wherein switching the two-way SMA from the second state to the first state causes the hinge apparatus to apply a closing force to the device coupled to the hinge apparatus.

2. The hinge apparatus of claim 1, wherein the hinge pin is a torque tube formed of a two-way SMA.

3. The hinge apparatus of claim 1, wherein:

one of the first and second states is an austenitic state of the two-way SMA; and

the other of said first and second states is a martensitic state of the two-way SMA.

4. The hinge apparatus of claim 3, wherein:

the hinge pin rotates into a twisted configuration upon switching the two-way SMA to the austenitic state; and

the hinge pin rotates into an untwisted configuration upon switching the two-way SMA to the martensitic state.

5. The hinge apparatus of claim 4, wherein the hinge pin rotates into an intermediate partially twisted configuration when a temperature of the two-way SMA is between an austenite temperature and a martensite temperature.

6. The hinge apparatus of claim 3, wherein:

the hinge pin rotates into an untwisted configuration upon switching the two-way SMA to the austenitic state; and

the hinge pin rotates into a twisted configuration upon switching the two-way SMA to the martensitic state.

7. The hinge apparatus of claim 6, wherein the hinge pin rotates into an intermediate partially twisted configuration when a temperature of the two-way SMA is between an austenite temperature and a martensite temperature.

8. The hinge apparatus of claim 1, further comprising a device to cause the hinge pin to heat and switch the two-way SMA between at least the first and second states.

9. The hinge apparatus of claim 1, wherein a door is coupled to the hinge apparatus such that switching the two-way SMA between the first and second states causes the hinge apparatus to apply an opening force or a closing force to the door.

10. The hinge apparatus of claim 9, wherein the hinge pin rotates to apply a force for partially opening or closing the door when a temperature of the two-way SMA is between an austenite temperature and a martensite temperature.

11. The hinge apparatus of claim 1, wherein the hinge pin is produced according to a method comprising thermal cycling a material under a sufficient load for a sufficient number of thermal cycles between about the material's austenite and martensite temperatures to complete training of the material, the thermal cycling conditioning the material to transition, without an externally applied load, between an austenitic shape and a martensitic shape to perform useful work when the material is thermally cycled between the austenite and martensite temperatures.

12. The hinge apparatus of claim 11, wherein the material is thermal cycled for about one thousand or more thermal cycles.

13. The hinge apparatus of claim 11, wherein the load applied to the material during said thermal cycling is about fifty percent more than a predicted working load for the hinge pin.

14. The hinge apparatus of claim 11, wherein the method further includes heat treating the material, prior to said thermal cycling, to establish the austenitic shape and to initiate shape memory effect in the material.

15. A method of controllably moving a device in a first direction and a second direction using only one shape memory alloy (SMA), the device being coupled to a hinge apparatus having a hinge pin formed of a two-way SMA, the method comprising:

moving the device in the first direction by switching the two-way SMA from a first state in which the hinge pin is in a first trained shape to a second state in which the hinge pin is in a second trained shape; and

moving the device in the second direction by switching the two-way SMA from the second state to the first state.

16. The method of claim 15, wherein:

switching the two-way SMA from the first state to the second state includes heating the two-way SMA to an austenite temperature to switch the two-way SMA to an austenitic state; and

switching the two-way SMA from the second state to the first state includes cooling the two-way SMA to a martensite temperature to switch the two-way SMA to a martensitic state.

17. The method of claim 15, wherein:

the device is in a first position when the hinge pin is in the first trained shape;

the device is in a second position when the hinge pin is in the second trained shape; and

the device is in an intermediate position generally between the first and second positions when a temperature of the two-way SMA is between an austenite temperature and a martensite temperature.

18. The method of claim 15, wherein:

the device coupled to the hinge apparatus is a door;

switching the two-way SMA from the first state to the second state causes the hinge pin to rotate to open the door; and

switching the two-way SMA from the second state to the first state causes the hinge pin to rotate to close the door.

19. The method of claim 15, further comprising making the hinge pin by thermal cycling a material under a sufficient load for a sufficient number of thermal cycles between about the material's austenite and martensite temperatures to complete training of the material, the thermal cycling conditioning the material to transition, without an externally applied load, between an austenitic shape and a martensitic shape to perform useful work when the material is thermally cycled between the austenite and martensite temperatures.

20. The method of claim 19, wherein the material is thermal cycled for about one thousand or more thermal cycles.

21. The method of claim 19, wherein the load applied to the material during said thermal cycling is about fifty percent more than a predicted working load for the hinge pin.

22. The method of claim 19, wherein the material is heated treated, prior to said thermal cycling, to establish the austenitic shape and to initiate shape memory effect in the material.

23. A method of making a two-way shape memory alloy part, the method comprising thermal cycling a material under a sufficient load for a sufficient number of thermal cycles between about the material's austenite and martensite temperatures to complete training of the material, the thermal cycling conditioning the material to transition, without an externally applied load, between an austenitic shape and a martensitic shape while performing useful work when the material is thermally cycled between the austenite and martensite temperatures.

24. The method of claim 23, wherein the material is thermal cycled for about one thousand or more thermal cycles.

25. The method of claim 23, wherein the load applied to the material during said thermal cycling is sufficient to cause the material to strain away from the austenitic shape generally towards the martensitic shape.

26. The method of claim 23, wherein the load applied to the material during said thermal cycling is about fifty percent more than a predicted working load for the finished part.

27. The method of claim 23, wherein the method further includes heat treating the material, prior to said thermal cycling, to establish the austenitic shape and to initiate shape memory effect in the material.

28. The method of claim 27, further comprising shaping the material into a desired shape prior to said heat treating, and wherein said heat treating establishes the desired shape as the austenitic shape.

29. A torque tube produced according to the method of claim 23.

30. A rotary actuator including the torque tube of claim 29.

31. A hinge apparatus including a hinge pin produced according the method of claim 23.